

Curriculum Vitae for Dr. Tania Moulik

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EDUCATIONAL QUALIFICATIONS

- April 2004 - Current: PostDoctoral Research Associate (DØ Experiment at Fermilab), University of Kansas, U.S.A.
- 1999-2003 : PostDoctoral Research Associate (CDF Experiment at Fermilab), Purdue University, U.S.A.
- 1993-1999 : Ph.D. in Physics
(Ph.D. Thesis : Determination of W mass at LEP2, Supervisor: Prof. A. Gurtu), Tata Institute of Fundamental Research(T.I.F.R), Mumbai, India.
- 1991-1993 : Master of Science in Physics, Delhi University, India.
- 1998-1991 : Bachelor of Science in Physics, Miranda House College, Delhi, India.

JOB EXPERIENCE AND DESCRIPTION

Activities in the DØ experiment at Fermilab

Working on DØ experiment under employment of University of Kansas (2004 - Present).

✧ **Calorimeter algorithm (CALGO) subgroup work**

I describe here work done in the above detector subgroup as part of service work for the experiment or work which is useful for general users.

- Central preshower validation - This is a subdetector made of three layers of scintillators with wave length shifting fibre (WLS) readout, and is installed between the calorimeter and the solenoid. It is useful for identifying low p_T electrons and photons. U. Kansas played a major role in the preshower reconstruction software, and cosmic ray calibration of the preshower. I worked on the reconstruction software and its validation. I validated the detector data to make sure that we are getting sensible data from this sub-detector. I used samples of photons converting to e^+e^- and $K_s \rightarrow \pi^+\pi^-$, for my studies and optimized the cuts on preshower variables in order to keep both the signal (electron) and fake (pion) rejection high.
- Soft Electron Identification - It is difficult to identify electron from b decays owing to the fact that they have low momenta (between 2 - 10 GeV) and are non-isolated (in the b-jet). I optimized calorimeter and preshower variables to demonstrate the capability of identifying and isolating low p_T electrons from background. The electron identification efficiency was studied in a photon conversion sample and estimated to be $\approx 80\%$. It achieved a fake rejection efficiency of 90% for pions from $K_s \rightarrow \pi^+\pi^-$.

✂ B Physics group related work

This describes work done in the above analysis group, individually or in conjunction with collaborators and students. I have also guided students during collaborative analyses and as head of analysis sub-groups. See below for details :

- Flavor tagging identifies the “flavor” of the B meson, whether it is composed of a quark or an anti-quark. Introduced **soft electron tagging** for the first time as an additional means of flavor tagging. The tag uses low p_T electrons down to 2 GeV, for identifying the flavor of a B meson using its semileptonic decay. This analysis also demonstrated a successful use of the Central Preshower subdetector. It adds about an 8% improvement to the tagging power.
- Worked on **combination of flavor taggers** including the electron tagging, for flavor tagging calibration and measurement of the B_d mixing parameter as a first step towards B_s mixing studies. Other collaborators developed the other taggers and this work was a collaborative effort. The first preliminary analysis shown at conferences was completed in May 2005.
- **Leader of the flavor tagging subgroup and measurement of B_d mixing** I headed the flavor tagging subgroup, and both worked and coordinated efforts on combination and validation of all flavor taggers, to reproduce the above results with further improvements and addition of luminosity. These efforts led to an improved B_d mixing parameter measurement using opposite side flavor tagging. The preliminary results for conferences were shown in Feb 2006 and the analysis was published in Phys. Rev. D in Nov 2006. I was one of the primary editors of the paper. This measurement is a crucial check of the flavor tagging calibration, and the tagging is then used for a study of B_s mixing. The analysis appeared in the “**Result of the week**” in Fermilab today. in Mar 2006. (http://www.fnal.gov/pub/today/archive_2006/today06-03-16.html)
- **Primary author of the PRL (Phys. Rev. Letter) paper on first upper bound on the B_s oscillation frequency** (see Selected List of Publications) The above work on combination and calibration of flavor taggers was an essential component of the B_s mixing analysis and the PRL paper which gave a first upper bound on the B_s oscillation frequency (see Selected List of Publications). I also introduced the decay mode $B_s \rightarrow D_s \nu_e X$, which uses an electron in the final state instead of a muon, as an additional channel for B_s mixing measurement, and this analysis was completed in June 2006 and has been presented at the ICHEP 2006 conference. It was recently updated with more data and was shown at Lepton-Photon 2007 as part of the combined Δm_s result from DØ.
- **Co-leader of the B_s mixing sub-group and measurement of B_s mixing** : In my role of co-leader of the B_s mixing sub-group, I coordinated and helped individual analysts and we updated the results on B_s mixing for the Lepton-Photon 2007 conference, obtaining a first preliminary **measurement of the Δm_s parameter** from the DØ experiment. I worked on the combination of the modes to obtain the combined result. The result is based on $2.4 fb^{-1}$ and can be found on the “Physics Results” webpages of the DØ experiment. The analysis was highlighted in Fermilab “**Result of the week**” (http://www.fnal.gov/pub/today/archive_2007/today07-10-04.html)
Currently, myself and Hal Evans (Indiana University) are convening the activities of the “B mixing and Lifetimes” sub-group with an aim to improve the above result with more data and work towards publication.

SUMMARY OF DØ ACTIVITIES

Within two years of joining the experiment, I contributed to two published analyses and was the

main editor for one of them. I demonstrated a successful use of low p_T electrons for analyses for the first time and have validated the preshower subdetector. I also completed a preliminary analysis (B_s mixing in electron mode) which has been approved for conferences and was recently updated for the Lepton-Photon 2007 conference. As convenor of the B_s mixing and lifetimes sub-group, I coordinated efforts to improve on the mixing result with the addition of more decay modes, data and other improvements which led to a measurement of the B_s mixing parameter. A combined preliminary measurement of the B_s mixing parameter was presented in the Lepton-Photon 2007 conference and is available in the $D\bar{D}$ physics results page. The result will be included by HFAG (Heavy flavor averaging group) in the combined world average. We are currently working towards a publication of this result.

Activities at CMS (Central Muon Solenoid) experiment at CERN

U. Kansas also participates in the CMS experiment and I have partly been involved in CMS related work since Oct 2005. I have worked on tracking algorithm development with the Fermilab tracking group and in particular implemented the pixel layers and code which can work both with and without the innermost layer (namely, the pixel detector), as the pixel detector may not be ready when CMS first starts data-taking. It is chaired by Kevin Burkett from Fermilab and Steve Wagner from U. Colorado. I have also worked on Data Quality Monitoring for the tracker data for the tracker commissioning tests. I have worked within the CMS remote monitoring group at Fermilab, also called CMSROC, headed by Kaori Maeshima and Alan Stone.

Activities at CDF (Collider detector at Fermilab) experiment

Worked at CDF experiment with Purdue University (1999-2003).

✧ Simulation group activities

As part of my service work, I worked in the simulation group on the introduction of TAUOLA package. This involved creating an interface between the AC++ framework which is an Object-Oriented general analysis framework written in C++ with the code written in Fortran. Was in touch with the author's of TAUOLA on implementing this package at CDF.

✧ Central Preradiator Offline Reconstruction

Responsible for the Central Preradiator offline reconstruction. This subdetector is a proportional wire chamber installed between the calorimeter and solenoid, and is useful for identifying low p_T electrons and photons. Code is written in C++ and I worked on the geometry implementation, track extrapolation to the sub-detector, and reconstruction of the preshower cluster, which gave the energy and position information of the particle. These codes were used in physics analyses which needed to identify photons and low momentum electrons.

✧ Soft Electron Tagging

Worked in the B physics group to implement soft electron tagging. Flavor tagging is very important for B_d and B_s mixing studies. The strategy for identifying soft electrons is somewhat different from the usual high P_T electrons, which is used for W and Z reconstruction, for example. I implemented the soft electron identification code (in C++), which does a clustering of the hit towers of the calorimeter after extrapolating a track to the calorimeter to find the hit position. I validated the soft electron identification, using electrons from photons converting to an e^+e^- pair in the detector. The rejection power of the cuts and variables was evaluated using pions from $K_S \rightarrow \pi^+\pi^-$ decays. This was one of the first studies to benchmark the soft electron identification and use of soft electron in B flavor tagging. First studies on soft

electron ID at CDF was presented in an APS conference (See Conferences). The soft electron tagging was studied using a high statistics B meson enriched lepton+displaced track sample.

SUMMARY OF CDF ACTIVITIES

I implemented the pre-radiator subdetector reconstruction and provided code maintenance. It was used in other analyses using photons and low p_T electrons. I implemented the code for soft electron identification and demonstrated a successful use of low p_T electrons in electron tagging for B physics studies.

Activities during Ph.D. program and Thesis (1993-1999)

I joined T.I.F.R., Mumbai, India, in Aug 1993 . The first one and half year was devoted to course work and projects. Besides the general physics courses, I took courses related to my research interest, which was a course on Particle Physics given by Prof. D.P. Roy which covered aspects of theoretical particle physics and on Experimental Particle Physics, given by Prof. Sunanda Banerjee which covered many aspects of accelerator and detector physics. My thesis was titled “Determination of W mass at LEP2” which was completed under the guidance of Prof. A. Gurtu, in 1999. Below, I give more details on work done during the Ph.D. program.

✧ **Physics Analysis Work**

After successful completion of course work, I joined the Experimental High Energy Physics (E.H.E.P.) Group in Aug 1994. T.I.F.R. was an active member of the L3 Collaboration at CERN since 1983. In July 1996, LEP (Large electron positron) collider crossed the W-production threshold. From 1996, I got involved in various aspects of W-Physics. I worked on the selection of $e^+e^- \rightarrow W^+W^- \rightarrow q\bar{q}e\nu$ events at three centre of Mass Energies $\sqrt{s} = 161 \text{ GeV}$ and $\sqrt{s} = 172 \text{ GeV}$ in 1996 and $\sqrt{s} = 183 \text{ GeV}$ in 1997. I also worked on the determination of the Mass and Width of the W boson (See Selected List of Publications).

– **Selection for $e^+e^- \rightarrow W^+W^- \rightarrow q\bar{q}e\nu$ decay mode:**

The selection for this decay mode involved identifying an isolated electron from energy deposits in the Electromagnetic Calorimeter and identifying a matching track in the tracking chamber TEC (Time Expansion Chamber) after which the remaining clusters were clustered into jets using standard jet clustering algorithms like Durham. Cuts had to be designed to get rid of background coming from other standard model processes, in particular $e^+e^- \rightarrow Z/\gamma \rightarrow q\bar{q}\gamma$, $e^+e^- \rightarrow Ze^+e^-$, $e^+e^- \rightarrow W^+W^- \rightarrow q\bar{q}\tau\nu$. The muon chamber was used to identify muons to get rid of $e^+e^- \rightarrow W^+W^- \rightarrow q\bar{q}\mu\nu$ events.

– **Determination of mass and width of the W boson :**

I included all events selected by other decay modes of the W boson pairs in this measurement and used my selection for the semi-electron mode. After identifying the lepton and jets, or all jets, one could derive the four-momenta of the jets, the electron (or muon) and the ν and then carry out a kinematic fitting to improve the resolution. These events were then used to extract the mass and width of the W boson. We used two independent methods, convolution and reweighting method and obtained $M_W = 80.90 \pm 0.36 \pm 0.06 \text{ GeV}$ and a width of $\Gamma_W = 2.1_{-0.8}^{+1.1} \pm 0.3$ from the convolution method and a very similar result using the reweighting method.

✧ **Hardware activities and Simulation work:**

I also contributed to the hardware activities in the group for the upcoming CMS Detector at LHC (Large Hadron Collider) and was part of the RD36 Collaboration (See Selected List

of publications). I participated in the work done on Shashlik design which was one of the options for the electromagnetic calorimeter for this detector. We worked on the study of light collection as a function of scintillator tile size ,using cosmic muons. During this work, I gained experience into aspects of DAQ, working with ADC's, functioning of PMT's and scintillators and light collection with WLS (Wavelength shifting) fibres. I also worked on a GEANT3 based simulation study of the effect of a Copper(Cu) Spacer in the HCAL Calorimeter of the CMS detector which was part of the calorimeter design.

TALKS AT CONFERENCES AND HEP SEMINARS

1. B Spectroscopy at the Tevatron, **ISMD 2007** - International Symposium on MultiParticle Dynamics, Aug 6-9, 2007, LBNL, Berkeley, CA, USA.
2. Flavor Tagging at CDF/D0 experiment incl. calibration and control, **Beauty 2006** - 11th International Conference on B-physics at Hadron Machines, September 25-29, 2006, Oxford, United Kingdom.
3. B_s mixing at DØ experiment, **ICHEP 2006** - 33rd International conference on High Energy Physics, Jul 26th - Aug 2nd 2006, Moscow, Russia. (presented : A. Nomerotski on behalf T. Moulik)
4. First Direct Two-sided Bound on Bs Oscillation at DØ Experiment, May 1 2006, Particle Physics Seminar, State University of New York(SUNY) at Stony Brook, USA.
5. First direct two-sided bound on Bs oscillation frequency, Apr 25 2006, HEP Seminar, University of Kansas, USA.
6. B_d and B_s mixing at DØ , **Beauty 2005** - 10th International Conference on B-Physics at Hadron Machines, June 20th - June 24th 2005, Asissi (Perugia), Italy.
7. B Physics at Tevatron, HEP Seminar, 22 Apr 2004, University of Kansas, USA.
8. Soft Electron Tagging with the CDF detector, **APS Meeting**, April 5 - 8, 2003, Philadelphia, Pennsylvania, USA.
9. LEP Summary on $W \rightarrow l\nu$, Fifth Workshop on Tau Lepton Physics, **TAU98**, 14-17 September, 1998, Santander, Spain.
10. Selection of $q\bar{q}e\nu$ and $q\bar{q}\mu\nu$ events at 183 GeV, L3 General Meeting, 14-19 June 1998, Ascona, Switzerland, Dec 1998, Chandigarh, India.
11. W Mass and Width by Convolution Method, L3 General Meeting, May 20-23 1997, Toledo, Spain.
12. W mass and width at L3 experiment, XIII DAE Symposium on High Energy Physics, Dec 1998, Chandigarh, India.
13. Selection of $e^+e^- \rightarrow W^+W^- \rightarrow q\bar{q}e\nu$ events and determination of W Mass at 161 GeV, XII th DAE Symposium on High Energy Physics, Dec 1996, Guwahati, India.

SCHOOLS AND WORKSHOPS

1. Workshop on B Physics at Tevatron - RunII and Beyond, Feb 24-26, 2000, Fermilab, Batavia, USA.
2. 1997 ICFA School on Instrumentation in Elementary Particle Physics, 7th Jul - 19th Jul 1997, Leon, Mexico.
3. II Experimental High Energy Physics SERC School, Jan 1997, Bombay, India.
4. X SERC School on Theoretical High Energy Physics, Benares Hindu University, India, 16th Feb - 14th Mar, 1995.
5. I SERC School on Experimental High Energy Physics, Bombay, India, Jan 15-28, 1995.

SELECTED LISTS OF PUBLICATIONS

1. **“Measurement of B_d mixing using opposite-side flavor tagging”**
V. M. Abazov *et al.* [D0 Collaboration],
Phys. Rev. D. **74**, 112002 (2006) [arXiv:hep-ex/0603034]
2. **“Direct limits on the B_s Oscillation Frequency”**
V. M. Abazov *et al.* [D0 Collaboration]
Phys. Rev. Lett. **97**, 021802 (2006) [arXiv:hep-ex/0603029]
3. **“Flavor Tagging at Tevatron incl. calibration and control,”**
T. Moulik [DØ Collaboration], Proceedings of the 11th International Conference on B-Physics at Hadron machines (Beauty 2006) Nucl. Phys. Proc. Suppl. **156**, 38 (2006).
4. **“ B_s mixing at DØ experiment,”** T. Moulik [DØ Collaboration], Proceedings of the 33rd International Conference on High Energy Physics (ICHEP 2006),
World Scientific, ISBN#9789812703859
5. **“Study of B oscillations at the D0 experiment,”** T. Moulik [DØ Collaboration], Proceedings of the 10th International Conference on B-Physics at Hadron machines (Beauty 2005) Nucl. Phys. Proc. Suppl. **156**, 38 (2006).
6. **“Measurement of the cross section of W-boson pair production at LEP”**
P. Achard *et al.* [L3 Collaboration]
Phys. Lett. B **600**, 22 (2004) [arXiv:hep-ex/0409016]
7. **“Studies of the response of the prototype CMS hadron calorimeter, including magnetic field effects, to pion, electron, and muon beams”**
V. V. Abramov *et al.* [CMS-HCAL Collaboration]
Nucl. Instrum. Meth. A **457**, 75 (2001) [arXiv:hep-ex/0007045]
8. **“LEP summary on $W \rightarrow l \nu$ ”**
T. Moulik [L3 Collaboration]
Nucl. Phys. Proc. Suppl. **76**, 83 (1999)
9. **“Measurement of mass and width of the W boson at LEP”**
M. Acciarri *et al.* [L3 Collaboration]
Phys. Lett. B **454**, 386 (1999) [arXiv:hep-ex/9909010]

10. **“Measurement of W pair cross sections in e+ e- interactions at $\sqrt{s} = 183$ -GeV and W decay branching fractions”**
M. Acciarri *et al.* [L3 Collaboration]
Phys. Lett. B **436**, 437 (1998)
11. **“Measurements of mass, width and gauge couplings of the W boson at LEP”**
M. Acciarri *et al.* [L3 Collaboration]
Phys. Lett. B **413**, 176 (1997)
12. **“Pair-production of W bosons in e+ e- interactions at $\sqrt{s} = 161$ -GeV”**
M. Acciarri *et al.* [L3 Collaboration]
Phys. Lett. B **398**, 223 (1997)
13. **“Measurement of W pair cross sections in e+ e- interactions at $\sqrt{s} = 172$ -GeV and W decay branching fractions”**
M. Acciarri *et al.* [L3 Collaboration]
Phys. Lett. B **407**, 419 (1997)
14. **“Beam Test Results Of A Shashlik Calorimeter In High Magnetic Field”**
P. Aspell *et al.* [RD36 Collaboration]
Nucl. Instrum. Meth. A **376**, 361 (1996)
15. **“Energy And Spatial Resolution Of A Shashlik Calorimeter And A Silicon Preshower Detector”**
P. Aspell *et al.* [RD36 Collaboration]
Nucl. Instrum. Meth. A **376**, 17 (1996)
16. **“A Shashlik + Preshower detector as electromagnetic calorimeter for LHC”**
P. Aspell *et al.* [RD-36 Collaboration]
CERN-DRDC-94-47

OTHER ACTIVITIES AND MEMBERSHIPS

1. Member of the American Physical Society (APS) since 2003.
2. Outreach : I have conducted tours of DØ experimental facility for high school students from time to time.
3. Chairperson of the Fermilab International Film society since 2006: Member of the society since 2004. Society organizes internationally acclaimed film shows every month in the Fermilab auditorium and serves as an outreach to the public. We also strive to connect people from diverse backgrounds working at Fermilab through films which create understanding and awareness of diverse countries and cultures.
(Webpage of the Fermilab Film Society)
4. Co-owner of the following mailing lists at Fermilab :
drishti@fnal.gov (Forum for Indian scientists at Fermilab)
fermiculture@fnal.gov (Forum for cultural activities at Fermilab)
film_society@fnal.gov, filmweb@fnal.gov (Fermilab film society activities and film questions forum)
postdocs@fnal.gov (Forum for postdoctorates)
d0bmixing@fnal.gov (DØ mixing sub-group activities)
d0-bphys@fnal.gov (DØ B physics group).